SERVICE WATER HEATING: Supply of hot water for purposes other than space heating.

SLAB-ON-GRADE FLOOR INSULATION: Insulation around the perimeter of the floor slab or its supporting foundation when the top edge of the floor perimeter slab is above the finished grade or 12 inches (305 mm) or less below the finished grade.

SOLAR ENERGY SOURCE: Source of natural daylighting and of thermal, chemical or electrical energy derived directly from conversion of incident solar radiation.

SUNROOM: An *addition* to an existing building/dwelling unit where the total area (rough opening or unit dimensions) of glazed fenestration products of said *addition* exceeds 40% of the combined gross wall and ceiling area of the *addition*.

SYSTEM: A combination of central or terminal equipment or components and/or controls, accessories, interconnecting means, and terminal devices by which energy is transformed so as to perform a specific function, such as HVAC, service water heating or illumination.

THERMAL CONDUCTANCE (C): Time rate of heat flow through a body (frequently per unit area) from one of its bounding surfaces to the other for a unit temperature difference between the two surfaces, under steady conditions (Btu/h·ft.^{2}·?F) [W/(m^{2}·k)].

THERMAL RESISTANCE (*R*): The reciprocal of thermal conductance (h·ft.^{2}·?F/Btu) [(m^{2}·K)/W].

THERMAL RESISTANCE, OVERALL (R_o): The reciprocal of overall thermal conductance (h·ft.^{2}·?F/Btu) [(m^{2}·k)/W]. The overall thermal resistance of the gross area or individual component of the exterior building envelope (roof/ceiling, exterior wall, floor, crawl space wall, foundation, window, skylight, door, or opaque wall, etc.) which includes the weighted *R*-values of the component assemblies (such as air-film, insulation, drywall, framing, glazing, etc.).

THERMAL TRANSMITTANCE (*U*): The coefficient of heat transmission (air to air). It is the time rate of heat flow per unit area and unit temperature difference between the warm side and cold side air films (Btu/h· ft.^{2}·?F) [W/(m^{2}·k)]. The *U*-value applies to combinations of different materials used in series along the heat flow path, single materials that comprise a building section, cavity air spaces and surface air films on both sides of a building element. The term **F-value** applies to U properties for concrete slabs.

THERMAL TRANSMITTANCE, OVERALL (U_o): The overall (average) heat transmission of a gross area of the exterior building envelope (Btu/h·ft.^{2}·?F) [W/(m^{2}·k)]. The U_o value applies to the combined effect of the time rate of heat flow through the various parallel paths, such as windows, doors and opaque construction areas, comprising the gross area of one or more exterior building components, such as walls, floors or roof/ceilings.

THERMOSTAT: An automatic control device actuated by temperature and designed to be responsive to temperature.

UNITARY COOLING AND HEATING EQUIPMENT: One or more factory-made assemblies which include an evaporator or cooling coil, a compressor and condenser combination, and may include a heating function as well. When heating and cooling equipment is provided in more than one assembly, the separate assemblies shall be designed to be used together.

UNITARY HEAT PUMP: One or more factory-made assemblies which include an indoor conditioning coil, compressor(s) and outdoor coil or refrigerant-to-water heat exchanger, including means to provide both heating and cooling

functions. When heat pump equipment is provided in more than one assembly, the separate assemblies shall be designed to be used together.

VENTILATION: The process of supplying or removing air by natural or mechanical means to or from any space. Such air may or may not have been conditioned.

VENTILATION AIR: That portion of supply air which comes from outside (outdoors) plus any recirculated air that has been treated to maintain the desired quality of air within a designated space. (See BOCA Mechanical Code, as listed in Appendix A, 780 CMR J3, and definition of "Outdoor air.")

WATER HEATER, NON-STORAGE: A water heater with an input rating of at least 4,000 Btu/h per gallon (310 W/L) stored water and a storage capacity of less than ten gallons (38 L).

WATER HEATER, STORAGE: A water heater with an input rating of less than 4,000 Btu/h per gallon (310 W/L) of stored water or storage capacity of at least ten gallons (38 L).

ZONE: A space or group of spaces within a building with heating and/or cooling requirements sufficiently similar so that comfort conditions can be maintained throughout by a single controlling device.

780 CMR J3.0 DESIGN CONDITIONS

J3.1 Design Criteria:

J3.1.1 General: The criteria of 780 CMR J3.0 establish the design conditions for use with 780 CMR J5, J6, J7, J8 and J9.

J3.2 Thermal Design Parameters

J3.2.1 Exterior design conditions. As applicable, the design parameters in Table J3.2.1 shall be used for calculations required under Appendix J.

TABLE J3.2.1
Exterior Design Conditions
Heating Degree Days Base 65 (HDD_{65})

	Outside Ambient			
Location	Heating Degrees (?F) Winter[1]	Cooling Degrees (?F) Dry Bulb Summer[1]	Cooling Degrees (?F) Wet Bulb Summer[1]	Heating Degree Days[2] Base 65
Boston	9	88	74	5641
Clinton	2	87	73	6698
Fall River	9	84	73	5774
Framingham	6	86	73	6262
Gloucester	5	86	74	-
Greenfield	-2	85	73	-
Lawrence	0	87	74	6322
Lowell	1	88	74	6339
New Bedford	9	82	73	5426
Pittsfield	-3	84	72	7578
Springfield	0	87	73	5754
Taunton	9	86	74	6346
Worcester	4	84	72	6979

For SI: ?F.=1.8?C. + 32.

1 The outdoor design temperature shall be selected from the columns of 97½% values for winter and 2½% values for summer from tables in the ASHRAE Handbook of Fundamentals, as listed in Appendix A. Adjustments may be made to reflect local climates which differ from the tabulated temperatures, or local weather experience determined by the building official.

2 The Degree Days Heating (base 65?F.) and cooling (base 65?F.) shall be selected from "NOAA Annual Degree Days to Selected Bases Derived from the 1961-1990 Normals," ASHRAE Handbook of Fundamentals, as listed in Appendix A, data available from adjacent military installations, Table J3.2.1, or other source of local weather data acceptable to the building official.

J3.2.2 Interior design conditions.

J3.2.2.1 Indoor design temperature: Indoor design temperature shall be 72?F for heating and 78?F for cooling.

J3.2.2.2 Design humidity: Indoor design relative humidity for heating shall not exceed 30%. For cooling, the actual design relative humidity within the comfort envelope as defined in ASHRAE Standard 55-92 listed in Appendix A shall be selected for minimum total HVAC system energy use in accordance with accepted practice.

J3.3 Living Space Ventilation Criteria.

J3.3.1 Ventilation: Living space fresh air ventilation shall conform to the requirements of 780 CMR 12 and the BOCA Mechanical Code, as listed in Appendix A.

Exception: If outdoor air quantities other than those specified in the BOCA Mechanical Code are used or required because of special occupancy or process requirements, source control of air contamination, health and safety, or other standards, the required outdoor air quantities shall be used as the basis for calculating the heating and cooling design loads.

780 CMR J4.0 GENERAL REQUIREMENTS

J4.1 Scope.

J4.1.1 General: All buildings that are mechanically heated or cooled and meet the provisions of Appendix J using the compliance paths of 780 CMR J5.0, J6.0, or J7.0 shall also meet the requirements of 780 CMR J4.0. Buildings that meet the provisions using the compliance paths of 780 CMR J8.0 or J9.0 are exempt from the requirements of 780 CMR J4.0.

Exception: All buildings must comply with the requirements of 780 CMR J4.2.1

J4.2 Building Envelope Requirements.

J4.2.1 Vapor Retarder: The design shall not create conditions of accelerated deterioration from moisture condensation. In all frame walls, floors, and ceilings not ventilated to allow moisture to escape, an approved vapor retarder having a maximum rating of 1.0 perm, when tested in accordance with Standard ASTM E 96, as listed in Appendix A, shall be installed on the warm-in-winter side of the thermal insulation.

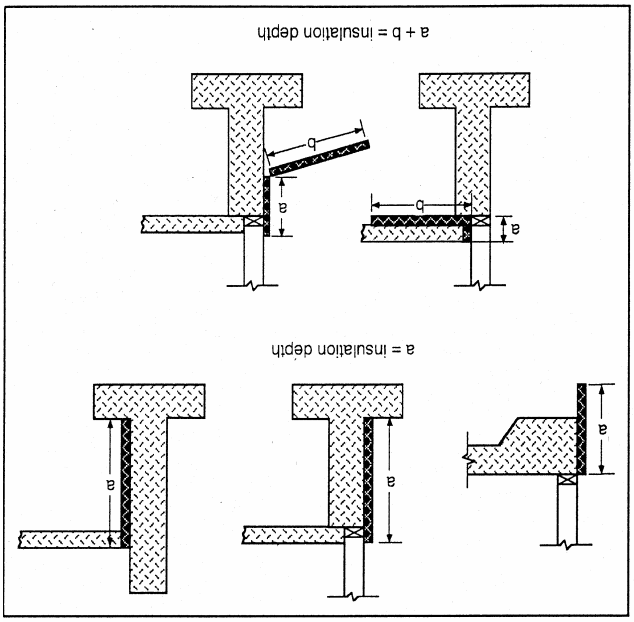
Exception: In construction where moisture or its freezing will not damage the materials or adversely affect the performance of the insulation.

J4.2.2 Basements: The exterior walls of basements below uninsulated floors shall be insulated from the top of the foundation wall to a depth of ten feet (3048 mm) below the outside finish ground level, or to the level of the basement floor, whichever is less. Basement walls shall be insulated if the basement is a conditioned space.

J4.2.3 Slab-on-grade floors: Insulation shall be placed on the outside of the foundation or on the inside of a foundation wall. In climates with less than 6,000 annual Fahrenheit heating degree days (HDD_{65}), the insulation shall extend downward from the elevation of the top of the slab for a

minimum distance of 24 inches (610 mm), or downward to at least the bottom of the slab and then horizontally to the interior or exterior for a minimum total distance of 24 inches (610 mm) and shall be an approved type. In climates equal to or greater than 6,000 annual Fahrenheit heating degree days (HDD_{65}), the insulation shall extend downward from the elevation of the top of the slab for a minimum of 48 inches (1219 mm), or downward to at least the bottom of the slab and then horizontally to the interior or exterior for a minimum total distance of 48 inches (1219 mm). In all climates, the horizontal insulation extending outside of the foundation shall be covered by pavement or by soil a minimum of ten inches (254 mm) thick. The top edge of the insulation installed between the exterior wall and the edge of the interior slab shall be permitted to be cut at a 45-degree angle away from the exterior wall. (see Figure J4.2.2.)

Figure J4.2.2
Typical Slab-on-grade Insulation Examples



J4.2.4 Crawl spaces: The floor above a crawl space shall be insulated to a minimum of R-19. See also 780 CMR 3603.6.8.2

J4.2.5 Access openings: Access doors, hatches, scuttles, pull down staircases and similar constructions that are part of the building envelope shall be insulated to a level equivalent to the insulation of the surrounding floor, wall, and ceiling.

Exception: If the access opening has less insulation than the surrounding area, for calculation purposes the U-value of the surrounding floor, wall, and ceiling shall be increased accordingly.

J4.2.6 Masonry veneer: When insulation is placed on the exterior of a foundation supporting a masonry veneer exterior, the horizontal foundation surface supporting the veneer is not required to be insulated to satisfy the foundation insulation requirement.

J4.2.7 Return-Air Ceiling Plenums: When return-air ceiling plenums are employed, the roof/ceiling assembly shall:

1. For thermal transmittance purposes, not include the ceiling proper nor the plenum space as part of the assembly; and,
2. For gross area purposes, be based upon the interior face of the upper plenum surface.

780 CMR J4.3 Air leakage.

J4.3.1 The requirements of 780 CMR J4.3 shall apply to those locations separating outdoor ambient conditions or exempted portions of the building (e.g.- attics, unconditioned basements) from interior conditioned spaces.The requirements are not applicable to the separation of interior conditioned spaces from each other.

J4.3.2 Window and Door Assemblies: Exterior doors and windows shall be designed to limit air leakage into and from the building envelope. Manufactured doors and windows shall comply with the maximum allowable infiltration rates in Table J4.3.2.

Exception: Site constructed windows and doors sealed in accordance with 780 CMR J4.3.3.

Table J4.3.2
Allowable Air Infiltration Rates[1]

Frame Type	Windows (cfm per ft of operable sash crack)	Doors (cfm per ft^2 of door area)	
Wood[2]	0.34	0.35[5]	0.5[6]
Alum[3]	0.37	0.37	0.5[6]
PVC[4]	0.37	0.37	0.5[6]

1. When tested in accordance with Standard ASTM E 283, as listed in Appendix A.
2. See Standard ANSI/NWWDA I.S.2, as listed in Appendix A.
3. See Standard ANSI/AAMA 101, as listed in Appendix A.
4. See Standards AAMA 101V and ASTM D 4099, each as listed in Appendix A.
5. Requirement based on door area specified in Standard ANSI/NWWDA I.S.3, as listed in Appendix A.
6. Requirement based on assembly area; except for manufactured (mobile) housing for which the requirement shall be 1.0 cfm/ft^2 (5.08 L/s/m^2) of door area; in accordance with Standard AAMA 1701.2 as listed in Appendix A.

J4.3.3 Joints, seams or penetrations in the building envelope that are sources of air leakage shall be sealed with durable caulking materials, closed with gasketing systems, taped or covered with moisture vapor permeable house-wrap per manufacturer's directions. Air leakage locations

to be treated shall include openings, cracks and joints between framing members and window or door frames; between wall assemblies or their sill-plates and foundations; between walls and roof/ceilings or attic/ceiling seals and between separate wall panels; between walls and floor assemblies; penetrations of utility services through walls, floors and roof assemblies, penetration through the wall cavity of top and/or bottom plates; and all other such openings in the building envelope. Sealing materials shall be compatible with the construction materials, location, and anticipated conditions. Sealing materials spanning joints between dissimilar construction materials shall allow for differential expansion and contraction of the construction materials.

This includes sealing around tubs and showers, at the attic and crawl space access panels, at recessed lights and around all plumbing, electrical, and HVAC penetrations. These are openings located in the building envelope between conditioned space and unconditioned space or between the conditioned space and the outside.

J4.3.4 Recessed lighting fixtures: When installed in the building envelope, recessed lighting fixtures shall meet one of the following requirements:

1. Type IC rated, manufactured with no penetrations between the inside of the recessed fixture and ceiling cavity and sealed or gasketed to prevent air leakage into the unconditioned space.
2. Type IC rated, in accordance with Standard ASTM E 283, as listed in Appendix A, with no more than 2.0 cfm (0.944 L/s) air movement from the conditioned space to the ceiling cavity. The lighting fixture shall have been tested at 75 Pa or 1.57 lbs/ft.^{2} pressure difference and shall be labeled.

J4.4 Building Mechanical Systems

J4.4.1 General: 780 CMR J4.4 covers the determination of heating and cooling loads, design requirements, system and component performance control requirements, insulating systems and duct construction.

Note: 780 CMR J4.4 addresses, in depth, requirements for "simple" heating and cooling systems. "Simple" systems are characterized as those typically found in one-and two-family houses (such as standard design boilers, furnaces, air conditioners, or heat pumps that provide heating and/or cooling). 780 CMR J4.4 also covers requirements for more "complex" systems (such as those designed to deliver heating and cooling simultaneously, evaporative coolers, water chillers, and others,) but such "complex" systems are only cited in this section, with reference to the other sections of 780 CMR where detailed criteria are given.

J4.4.2 Calculation of heating and cooling loads:

J4.4.2.1 Calculation procedures: For the purpose of sizing HVAC systems, heating and cooling design loads shall be determined in accordance with techniques recommended in the ASHRAE Handbook of Fundamentals or the Air Conditioning Contractors Association's Manual "J", or other procedure approved by the Board of Building Regulations and Standards. The design parameters specified in 780 CMR J3.0 shall apply for all computations.

J4.4.2.1.1 System heating/cooling capacity: The rated output capacity of the heating/cooling system at design conditions shall not be greater than 125% of the design load calculated in accordance with this article. Equipment designed for standby purposes is not included in the capacity limitation requirement. For a single piece of equipment which has both heating and cooling capability, only one function, either the heating or the cooling, need meet the requirements of 780 CMR J4.4. Capacity for the other function shall be, within available equipment options, the smallest size necessary to meet the load.

Exception 1: If the rated output capacity of available equipment options exceeds 125% of the design load, then equipment with the smallest output capacity above 125% of the load shall be utilized.

Exception 2: Where the HVAC system for the building uses interconnected equipment designed to sequence with the load and it can be shown that such design will use less energy on an annual basis than one large unit.

J4.4.2.1.3 Simultaneous heating and cooling: See 780 CMR 1305.3.5.

J4.4.2.2 Infiltration: Infiltration for heating and cooling design loads shall be calculated for all buildings except one- and two-family dwellings by the procedures in Chapter 22 of the ASHRAE Handbook of Fundamentals. Calculations for one and two family dwellings may use the methods identified above or other accepted engineering practices.

J4.4.3 HVAC equipment performance requirements.

J4.4.3.1 Equipment and components:

J4.4.3.1.1 The requirements of 780 CMR J4.4.3.1 apply to equipment and mechanical component performance for heating, ventilating, and air-conditioning systems. Equipment efficiency levels are specified. Data furnished by the equipment supplier or certified under a nationally recognized certification program or rating procedure shall be used to satisfy these requirements.

J4.4.3.1.2 Where components from more than one manufacturer are assembled into systems regulated under 780 CMR J4.4.3, compliance shall be as specified in 780 CMR J4.4.3.2 through J4.4.3.6.

J4.4.3.1.3 Omission of minimum performance requirements for certain classes of HVAC equipment does not preclude use of such equipment where appropriate.

J4.4.3.2 HVAC system combustion equipment: Gas- and oil-fired comfort heating equipment shall have minimum efficiency levels not less than the values in Table J4.4.3.2a through J4.4.3.2c.

TABLE J4.4.3.2a
GAS- AND OIL-FIRED STEAM AND HOT WATER BOILERS-
STANDARD RATING CONDITIONS AND MINIMUM PERFORMANCE

REFERENCE STANDARD	CATEGORY	RATING CONDITION	MINIMUM PERFORMANCE	
Code of Federal Regulations, 10 CFR	Gas-Fired <300,000 Btu/h	Seasonal Rating	AFUE	80%[3,4]
Part 430, Subpart B, Appendix N	Oil-Fired <300,000 Btu/h	Seasonal Rating	AFUE	80%[3]
ANSI Z21.13, as listed in Appendix A	Gas-Fired ?300,000 Btu/h	1. Maximum Rating Capacity[1] Steady-State	E_c [2]	80%
ANSI/ASME PTC 4.1, UL 795, each as listed in Appendix A		2. Minimum Rating Capacity[1] Steady-State		
UL 726, as listed in Appendix A	Oil-Fired ?300,000 Btu/h	1. Maximum Rating Capacity[1] Steady-State	E_c [2]	83%
ANSI/ASME PTC 4.1, as listed in Appendix A		2. Minimum Rating Capacity[1] Steady-State		
Hydronics Institute, Testing & Ratings Standard for Heating Boilers, 1982 ANSI/ASME PTC 4.1, as listed in Appendix A	Oil-Fired (Residual)	1. Maximum Rating Capacity[1] Steady-State	E_c [2]	83%
	?300,000 Btu/h	2. Minimum Rating Capacity[1] Steady-State		

For SI: 1 Btu/h = 0.2931 W.
1 Provided and allowed by the controls.
2 E_c = combustion efficiency, 100% minus flue losses. See reference standard for detailed information.
3 To be consistent with National Appliance Energy Conservation Act of 1987 (Public Law 100-12).
4 Except for gas-fired steam boilers for which minimum AFUE is 75%.

TABLE J4.4.3.2b

WARM AIR DUCT FURNACES AND UNIT HEATERS-
STANDARD RATING CONDITIONS AND MINIMUM PERFORMANCE

REFERENCE STANDARD	CATEGORY	RATING CONDITION	MINIMUM PERFORMANCE
ANSI Z83.9, as listed in Appendix A	Duct Furnaces Gas-Fired	1. Maximum Rating Capacity[1] Steady-State	E_t [2] 78%
		2. Minimum Rating Capacity[1] Steady-State	E_t [2] 75%
ANSI Z83.8, as listed in Appendix A	Unit Heaters Gas-Fired	1. Maximum Rating Capacity[1] Steady-State	E_t [2] 78%
		2. Minimum Rating Capacity[1] Steady-State	E_t [2] 74%
UL 731, as listed in Appendix A	Unit Heaters Oil-Fired	1. Maximum Rating Capacity[1] Steady-State	E_t [2] 81%
		2. Minimum Rating Capacity[1] Steady-State	E_t [2] 81%

1 Provided and allowed by the controls.
2 E_t = thermal efficiency, 100% minus flue losses. See reference standard for detailed definition.

TABLE J4.4.3.2c
WARM AIR FURNACES AND COMBINATION WARM AIR FURNACES/AIR-CONDITIONING UNITS- STANDARD RATING CONDITIONS AND MINIMUM PERFORMANCE

REFERENCE STANDARD	CATEGORY	RATING CONDITION	MINIMUM PERFORMANCE
Code of Federal Regulations, 10 CFR	Gas-Fired <225,000 Btu/h	Seasonal Rating	AFUE 78%[3] E_t[2] 80%
Part 430, Subpart B, Appendix N	Oil-Fired <225,000 Btu/h	Seasonal Rating	AFUE 78%[3] E_t[2] 80%
ANSI Z21.47, as listed in Appendix A	Gas-Fired ?225,000 Btu/h	1. Maximum Rating Capacity[1] Steady-State	E_t[5] 80%
		2. Minimum Rating Capacity[1] Steady-State	E_t[4] 78%
UL 727, as listed in Appendix A	Oil-Fired ?225,000 Btu/h	1. Maximum Rating Capacity[1] Steady-State	E_t[4] 81%
		2. Minimum Rating Capacity[1] Steady-State	E_t[4] 81%

For SI: ?F. = 1.8?C. + 32, 1 Btu/h = 0.2931 W.
1 Minimum and maximum ratings as provided for and allowed by the unit's controls.
2 These requirements apply to combination units not covered by NAECA (three phase power or cooling capacity > 65,000 Btu/h).
3 This is used to be consistent with National Appliance Energy Conservation Act (NAECA) of 1987 (Public Law 100-12). These values apply to furnace and combination units covered by NAECA.
4 See referenced standard for detailed definition of thermal efficiency (E_t) = (100% minus flue losses).

J4.4.3.3 HVAC system heating equipment, heat pump, heating mode. Heat pumps whose purchased energy input is entirely electric shall have efficiency levels for heating not less than the values in Table J4.4.3.3a through J4.4.3.3d. (NOTE: When more than one rating condition is listed by the manufacturer for a single piece of equipment, the rating type closer to the intended design conditions should be chosen.)

J4.4.3.3.1 780 CMR J4.4.3 applies to, but is not limited to, unitary (central) heat pumps (air source and water source) in the heating mode, to water-source (hydronic) heat pumps as used in multiple-unit hydronic HVAC systems, and to heat pumps in the packaged terminal air-conditioner and room air-conditioner forms in the heating mode.

TABLE J4.4.3.3a
HEAT PUMPS - AIR COOLED, ELECTRICALLY-OPERATED, <135,000 Btu/h COOLING CAPACITY STANDARD RATING CONDITIONS AND MINIMUM PERFORMANCE

REFERENCE STANDARD[1]	CATEGORY	SUB-CATEGORY & RATING CONDITIONS (Outdoor Temperature ?F.)[2]	MINIMUM PERFORMANCE
ARI 210/240, as listed in Appendix	<65,000 Btu/h	Seasonal Rating[1]	

A			
	Cooling Capacity	Split systems	6.8 HSPF
	Heating Mode	Single Package	6.6 HSPF
	(Heat Pump)		
	≥65,000 Btu/h	Split Systems & Single Package	
	<135,000 Btu/h	High Temperature Rating	3.0 COP
	Cooling Capacity	(47?F db/43?F wb)	
	Heating Mode	Low Temperature Rating	2.0 COP
		(17?F db/15?F wb)	

For SI: ?F = 1.8?C + 32, 1 Btu/h = 0.2931 W.
1 For multi-capacity equipment, the minimum performance shall apply to each capacity step provided. Multi-capacity refers to manufacturer published rating for more than one capacity mode allowed by the products' controls.
2 db = dry bulb; wb = wet bulb.

TABLE J4.4.3.3b
PACKAGED TERMINAL HEAT PUMPS - AIR COOLED, ELECTRICALLY OPERATED
STANDARD RATING CONDITIONS AND MINIMUM PERFORMANCE

REFERENCE STANDARD	CATEGORY PTAC HEAT PUMPS	SUB-CATEGORY & RATING CONDITIONS (Outdoor Temperature ?F)[1]	EFFICIENCY RATING	MINIMUM PERFORMANCE[2]
ARI 380, as listed in Appendix A	Heating Mode	Standard Rating (47?F db/43?F wb)	COP	2.9 - (0.026 x Cap/1,000)

For SI: ?F = 1.8?C + 32, 1 Btu/h = 0.2931 W.
1 db = dry bulb; wb = wet bulb.
2 Capacity (Cap) means the rated cooling capacity of the product in Btu/h in accordance with Standard ANSI Z21.13, as listed in Appendix A. If the unit's capacity is less than 7,000 Btu/h, use 7,000 Btu/h in the calculation. If the unit's capacity is greater than 15,000 Btu/h, use 15,000 Btu/h in the calculation.

TABLE J4.4.3.3c
WATER-SOURCE AND GROUNDWATER SOURCE HEAT PUMPS - ELECTRICALLY-OPERATED <135,000 Btu/h COOLING CAPACITY
STANDARD RATING CONDITIONS AND MINIMUM PERFORMANCE

REFERENCE STANDARDS	RATING CONDITION ?F[1]	MINIMUM PERFORMANCE
Water Source Heat Pumps: ARI 320, as listed in Appendix A	Standard Rating 70?F entering water[2]	3.8 COP
Groundwater-Source Heat Pumps: ARI 325, as listed in Appendix A	1. High Temperature Rating 70?F entering water[3]	3.4 COP
	2. Low Temperature Rating 50?F entering water[3]	3.0 COP

For SI:??F = 1.8?C + 32.
1 Air entering indoor section 70?F db/60?F wb (max.).
2 Water flow rate per manufacturer's specifications.

TABLE J4.4.3.3d
LARGE UNITARY HEAT PUMPS - AIR COOLED HEATING MODE-ELECTRICALLY-OPERATED > 135,000 Btu/h COOLING CAPACITY
STANDARD RATING CONDITIONS AND MINIMUM PERFORMANCE

REFERENCE STANDARDS	EFFICIENCY RATING	MINIMUM PERFORMANCE
ARI 340, as listed in Appendix A	COP (47?F)	2.9
Unitary Heat Pump Equipment	COP (17?F)	2.0

J4.4.3.3.2 Heat Pump Supplementary heater. The rated output capacity of a heat pump supplementary heating source shall not be greater than 125% of the design load as calculated in accordance with 780 CMR J4.4.2.1. The heat pump shall be installed with a control to prevent supplementary heater operation when the operating load can be met by the heat pump alone.

Supplementary heater operation is permitted during transient periods, such as start-ups, following room thermostat set-point advance and during defrost.

A two-stage thermostat, which controls the supplementary heat on its second stage, shall be

accepted as meeting this requirement. The cut-on temperature for the compression heating shall be lower than the cut-on temperature for the supplementary heat, and the cut-off temperature for the compression heating shall be lower than the cut-off temperature for the supplementary heat. Supplementary heat may be derived from any source including, but not limited to, electric resistance, combustion heating or solar or stored-energy heating.

J4.4.3.4 HVAC system equipment, electrically operated, cooling mode. HVAC system equipment whose energy input in the cooling mode is entirely electric, shall have efficiency levels not less than the values in Tables J4.4.3.4a through J4.4.3.4f.

TABLE J4.4.3.4a
UNITARY AIR CONDITIONERS AND HEAT PUMPS - AIR COOLED, ELECTRICALLY OPERATED, <135,000 Btu/h COOLING CAPACITY - EXCEPT PACKAGED TERMINAL AND ROOM AIR CONDITIONERS STANDARD RATING CONDITIONS AND MINIMUM PERFORMANCE

REFERENCE STANDARD	CATEGORY	SUB-CATEGORY & RATING CONDITIONS (Outdoor Temperature ?F)[1]	MINIMUM PERFORMANCE
ARI 210/240, as listed in Appendix A	<65,000 Btu/h Cooling Capacity Cooling Mode	Seasonal Rating[2]	
		Split systems	10.0 SEER
		Single Package	9.7 SEER
	?65,000 Btu/h and <135,000 Btu/h Cooling Capacity Cooling Mode	Standard Rating (95?F db)	8.9 EER
		Integrated Part Load Value (80?F db)	8.3 IPLV

For SI: ?F = 1.8?C + 32, 1 Btu/h = 0.2931 W.
1 db = dry bulb.
2 This is consistent with the National Appliance Energy Conservation Act of 1987 (Public Law 100-12).

TABLE J4.4.3.4b
UNITARY AIR CONDITIONERS AND HEAT PUMPS - EVAPORATIVELY COOLED, ELECTRICALLY OPERATED, AND COOLING MODE <135,000 Btu/h COOLING CAPACITY EXCEPT PACKAGED TERMINAL AND ROOM AIR CONDITIONERS STANDARD RATING CONDITIONS AND MINIMUM PERFORMANCE

REFERENCE STANDARD	CATEGORY (Cooling Capacity)	RATING CONDITIONS (Temperature ?F)[1] INDOOR	OUTDOOR	MINIMUM PERFORMANCE
ARI 210/240, as listed in Appendix A	<65,000 Btu/h	Standard Rating 80?F db/67?F wb	95?F db/75?F wb	9.3 EER
CTI Standard 201, as listed in Appendix A	<65,000 Btu/h	Integrated Part Load Value (80?F db/67?F wb)		8.5 IPLV
	≥65,000 but <135,000 Btu/h	Standard Rating 80?F db/67?F wb	95?F. db/75?F wb	10.5 EER
	≥65,000 but <135,000 Btu/h	Integrated Part Load Value (80?F db/67?F wb)		9.7 IPLV

For SI: ?F = 1.8?C + 32, 1 Btu/h = 0.2931 W.
1 db = dry bulb; wb = wet bulb.

TABLE J4.4.3.4c
WATER COOLED AIR CONDITIONERS AND HEAT PUMPS - ELECTRICALLY OPERATED, AND COOLING MODE <135,000 Btu/h COOLING CAPACITY STANDARD RATING CONDITIONS AND MINIMUM PERFORMANCE

REFERENCE	CATEGORY	RATING CONDITIONS INDOOR AIR	ENTERING WATER	MINIMUM

STANDARD	(Cooling Capacity)	(Temperature ?F)[1]		PERFORMANCE
Water Source Heat Pump ARI 320, as listed in Appendix A CTI Standard 201, as listed in Appendix A	<65,000 Btu/h	Standard Rating 80?F db/67?F wb	85?F	9.3 EER
		Low Temperature Rating 80?F db/67?F wb	75?F	10.2 EER
	?65,000 but <135,000 Btu/h	Standard Rating 80?F db/67?F wb	85?F	10.5 EER
Groundwater Cooled Heat Pumps ARI 325, as listed in Appendix A	<135,000 Btu/h	Standard Rating	70?F	11.0 EER
		Low Temperature Rating	50?F	11.5 EER
Water Cooled Unitary Air Conditioners ARI 210/240, as listed in Appendix A CTI Standard 201, as listed in Appendix A	≤65,000 Btu/h	Standard Rating 80?F db/67?F wb	85?F	9.3 EER
		Integrated Part Load Value	75?F	8.3 IPLV
	?65,000 but <135,000 Btu/h	Standard Rating 80?F db/67?F wb	85?F	10.5 EER

For SI: ?F = 1.8?C + 32, 1 Btu/h = 0.2931 W.
1 db = dry bulb; wb = wet bulb.

TABLE J4.4.3.4d
PACKAGED TERMINAL AIR CONDITIONERS - AIR COOLED, ELECTRICALLY OPERATED
STANDARD RATING CONDITIONS AND MINIMUM PERFORMANCE

REFERENCE STANDARD	CATEGORY PTAC's & PTAC HEAT PUMPS	SUB-CATEGORY & RATING CONDITIONS (Outdoor Temperature)[1]	EFFICIENCY RATING	MINIMUM PERFORMANCE[2]
ARI Standard 310, as listed in Appendix A	Cooling Mode	Standard Rating (95?F db)	EER	10.0 - (0.16 x Cap/1,000)
		Low Temperature Rating (82?F db)	EER	12.2 - (0.20 x Cap/1,000)

For SI: ?F = 1.8?C + 32, 1 Btu/h = 0.2931 W.
1 db = dry bulb.
2 Capacity (Cap) means the rated cooling capacity of the product in Btu/h in accordance with the cited ARI Standard. If the unit's capacity is less than 7,000 Btu/h, use 7,000 Btu/h in the calculation. If the unit's capacity is greater than 15,000 Btu/h, use 15,000 Btu/h in the calculation.

TABLE J4.4.3.4e
ROOM AIR CONDITIONERS AND ROOM AIR CONDITIONER HEAT PUMPS
STANDARD RATING CONDITIONS AND MINIMUM PERFORMANCE

REFERENCE STANDARDS	CATEGORY	MINIMUM PERFORMANCE[1]
ANSI/AHAM RAC-1-, as listed in Appendix A	Without Reverse Cycle and With Louvered Sides	
	<6,000 Btu/h	8.0 EER
	≥6,000 Btu/h and <8,000 Btu/h	8.5 EER
	≥8,000 Btu/h and <14,000 Btu/h	9.0 EER
	≥14,000 Btu/h and <20,000 Btu/h	8.8 EER
	≥20,000 Btu/h	8.2 EER
	Without Reverse Cycle and Without Louvered Sides	
	<6,000 Btu/h	8.0 EER
	≥6,000 Btu/h and <20,000 Btu/h	8.5 EER
	≥20,000 Btu/h	8.2 EER
	With Reverse Cycle and With Louvered Sides	8.5 EER
	With Reverse Cycle and Without Louvered Sides	8.0 EER

For SI: 1 Btu/h = 0.2931 W.
1 To be consistent with National Appliance Energy Conservation Act of 1987 (Public Law 100-12).

TABLE J4.4.3.4f
LARGE UNITARY AIR CONDITIONERS AND HEAT PUMPS ELECTRICALLY-OPERATED >135,000 Btu/h COOLING CAPACITY
STANDARD RATING CONDITIONS AND MINIMUM PERFORMANCE

REFERENCE STANDARDS	EFFICIENCY RATING	MINIMUM PERFORMANCE	
Air-Conditioners	EER	≤760,000 Btu/h: 8.5	>760,000 Btu/h: 8.2
Air Cooled ARI 360, as listed in Appendix A	IPLV	7.5	
Air-Conditioners	EER	9.6	

Water/Evap. Cooled CTI Standard 201, ARI 360, each as listed in Appendix A	IPLV	0.9	
Heat Pumps[1]		<760,000 Btu/h 8.5	?760,000 Btu/h 8.2
Air Cooled-Cooling	EER		
ARI 340, as listed in Appendix A	IPLV	7.5	
Condensing Units[2]	EER	9.9	
Air Cooled ARI 365, as listed in Appendix A	IPLV	11.0	
Condensing Units[2]	EER	12.9	
Water/Evap. Cooled CTI Standard 201, ARI 365, each as listed in Appendix A	IPLV	12.9	

For SI: 1 Btu/h = 0.2931 W.
1 For units that have a heating section, deduct 0.2 from all required EER's and IPLV's.
2 Condensing unit requirements are based on single-number ratings defined in paragraph 5.1.3.2 of UL 731, as listed in Appendix A

J4.4.3.5 Mechanical Ventilation: Each mechanical ventilation system (supply and/ or exhaust) shall be equipped with a readily accessible switch or other means for shutoff or volume reduction and shutoff when venti-lation is not required. Automatic or gravity dampers that close when the system is not operating, or other acceptable method to prevent air leakage through ducts, shall be provided for outdoor air intake and exhausts.

J4.4.3.5.1 780 CMR J4.4.3.5 applies to, but is not limited to, unitary (central) cooling equipment (air cooled, water cooled and evaporatively cooled), the cooling mode of unitary (central) and packaged terminal heat pumps (air source and water source), and packaged terminal air conditioners and room air conditioners.

J4.4.3.6 Applied HVAC system components, electrically operated, cooling mode: See 780 CMR 1305.3.3c.

J4.4.4 Transport energy: See 780 CMR 1305.3.9.

J4.4.5 Balancing: The HVAC system design shall provide means for balancing air and water systems. In doing so, the considerations shall include, but not be limited to, dampers, temperature and pressure test connections and balance valves.

J4.4.6 Controls.

J4.4.6.1 Temperature control: Each system shall be provided with at least one adjustable thermostat for the regulation of temperature. Each thermostat shall be capable of being set by adjustment or selection of sensors as follows:

J4.4.6.1.1 When used to control heating only: 55 to 75?F (12.8 to 23.9?C).

J4.4.6.1.2 When used to control cooling only: 70 to 85?F (21.1 to 29.4?C).

J4.4.6.1.3 When used to control both heating and cooling, it shall be capable of being set from 55 to 85?F (12.8 to 29.4?C) and shall be capable of operating the system heating and cooling in sequence. The thermostat and/or control system shall have an adjustable deadband of 10?F (5.6?C) or more.

J4.4.6.2 Humidity control:See 780 CMR 1305.2.4.2, 1305.3.4.5, and 1305.3.4.6.

J4.4.6.3 Zoning for temperature control.

J4.4.6.3.1 One and two family dwellings: At least one thermostat for regulation of space temperature shall be provided for each separate HVAC system. In addition, a readily accessible manual or automatic means shall be provided to partially restrict or shut off the heating and/or cooling input to each zone or floor.

J4.4.6.3.2 Multifamily dwellings three stories or less in height: For multifamily dwellings, each individual dwelling unit shall have at least one thermostat for regulation of space temperature. A readily accessible manual or automatic means shall be provided to partially restrict or shut off the heating and/or cooling input to each room. For spaces other than living units at least one thermostat for regulation of space temperature shall be provided for:

1. Each separate system.
2. Each separate zone as defined in 780 CMR J2.

As a minimum, each floor of a building shall be consid-ered as a separate zone. In a multi-story building where the perimeter system offsets only the transmission losses of the exterior wall, an entire side of uniform exposure may be zoned separately. A readily accessible manual or automatic means shall be provided to partially restrict or shut off the heating and/or cooling input to each floor.

J4.4.6.3.3 Control setback and shutoff: The thermostat required in 780 CMR J4.4.6.3.1 and J4.4.6.3.2 or an alternate means, including, but not limited to, a switch or a clock, shall provide a readily accessible manual or automatic means for reducing the energy required for heating and cooling during periods of non-use or reduced need including, but not limited to, unoccupied periods and sleeping hours. Lowering thermostat set points to reduce energy consumption of heating systems shall not cause energy to be expended to reach the reduced setting.

J4.4.7 Air-handling duct system insulation: Ducts, plenums, and enclosures installed in or on buildings shall be thermally insulated as follows:

J4.4.7.1 Duct systems, or portions thereof, shall be insulated to provide thermal resistance, as specified in Table J4.4.7.1.

Exceptions: Duct insulation, except as required to prevent condensation, is not required in the following cases:

1. When supply- or return-air ducts are installed in basements or cellars having insulated walls.
2. When the heat gain or loss of the ducts, without insulation, will not increase the energy requirements of the building.
3. Within HVAC equipment.
4. Exhaust air ducts.

TABLE J4.4.7.1
MINIMUM DUCT INSULATION[1]

	COOLING[2]		HEATING[3]	
Duct location	Annual Cooling Degree Days base 65?F CDD	Insulation *R*-Value[7] (h·ft²·?F)/Btu	Annual Heating Degree Days base 65?F	Insulation *R*-Value[7] (h·ft²·?F)/Btu
Exterior of building	below 500	3.3	4,501 to 7,500	6.5
	500 to 1,150	5.0	above 7,500	8.0
Inside of building envelope or in unconditioned spaces[4]				
TD[5] ≤ 15	—	Not Required	—	Not Required
40 ≥ TD[5] > 15	—	3.3	—	3.3
TD[5] > 40	—	5.0[6]	—	5.0[6]

For SI: ?F = 1.8?C + 32, 1 (h·ft²·?F)/Btu = 0.176 m²·k/W, 1 ft = 304.5 mm.

1. Insulation *R*-values shown are for the insulation as installed and do not include film resistance. The required minimum thicknesses do not consider water vapor transmission and condensation. Where control of condensation is required, additional insulation, vapor retarders, or both, shall be provided to limit vapor transmission and condensation. For ducts which are designed to convey both heated and cooled air, duct insulation shall be as required by the most restrictive condition. Where exterior walls are used as plenum walls, wall insulation shall be as required by the most restrictive condition of 780 CMR J4.4.7.
2. Cooling ducts are those designed to convey mechanically cooled air or return ducts in such systems.
3. Heating ducts are those designed to convey mechanically heated air or return ducts in such systems.
4. Unconditioned spaces include basements, crawl spaces, and attics.
5. TD is defined as the temperature difference at design conditions between the space within which the duct is located and the design air temperature in the duct.
6. Insulation resistance for runouts to terminal devices less than ten feet in length is not required to exceed an R-value of R-3.3. [(h·ft²·?F)/Btu.]
7. Insulation resistance measured on a horizontal plane in accordance with ASTM C 518-85, Test Method for Steady State Heat Flux Measurements and Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus, at a mean temperature of 75?F at the installed thickness.

J4.4.8 Duct construction: As applicable, ductwork shall be constructed and erected in accordance with:

ACCA Manual D;
BOCA National Mechanical Code;
ASHRAE Handbook HVAC Systems and Equipment;
SMACNA, Installation Standards for Residential Heating and Air Conditioning Systems;
SMACNA, HVAC Duct Construction Standards - Metal and Flexible;
SMACNA Fibrous Glass Duct Construction Standards;
ASHRAE HVAC Applications Handbook;
NAIMA Fibrous Glass Duct Construction Standards, each as listed in Appendix A.

J4.4.8.1 High-pressure and medium-pressure ducts: See 780 CMR 1305.3.13.2.

J4.4.8.2 Duct sealing: The accessible joints, seams, and connections of all low-pressure supply and return ductwork that is located outside conditioned space, including stud bays or joist cavities/spaces used to transport air, shall be sealed using mastic with fibrous backing tape installed in accordance with the manufacturer's installation instructions. Other sealants may be approved by the Board of Building Regulations and Standards. For fibrous ducts, pressure sensitive tape may be used if installed in accordance with NAIMA Fibrous Glass Duct Construction Standards, as listed in Appendix A. Duct tape is not permitted as a sealant on any ducts.

Exception 1: Fibrous backing tape need not be used in the following cases:
1. On duct connections which are overlapped.
2. Where gaps are less than 1/8" in any dimension.
3. On flex duct connections with properly installed tension straps.

Exception 2: Lengthwise snap-lock joints on round or rectangular ducts need not be sealed if they are tight fitting.

J4.4.9 Piping insulation: Piping installed for space conditioning shall be thermally insulated in accordance with Table J4.4.9. For service water-heating systems, see 780 CMR J4.5.

Exceptions: Piping insulation is not required in the following cases:
1. Piping installed within HVAC equipment.
2. Piping at fluid temperatures between 55?F and 120?F (12.7?C and 48.9?C) when not required for energy conservation purposes.
3. When the heat loss and/or heat gain of the piping without insulation does not increase the energy requirement of the building.
4. When piping is installed in basements or cellars having insulated walls in one and two family dwellings.

TABLE J4.4.9
MINIMUM PIPE INSULATION[1] (Thickness in Inches)

PIPING SYSTEM TYPES	FLUID TEMPERATURE RANGE, ?F	Pipe Sizes					
		Run Outs 2"[2]	1" and Less	1¼" to 2"	2½" to 4"	5" to 6"	8" and Larger
HEATING SYSTEMS Steam and hot water High pressure/temp	306-450	1½	2½	2½	3	3½	3½
Med. pressure/temp	251-305	1½	2	2½	2½	3	3
Low pressure/temp	201-250	1	1½	1½	2	2	2

Low temperature	120-200	½	1	1	1½	1½	1½
Steam condensate (for feed water)	Any	1	1	1½	2	2	2
COOLING SYSTEMS Chilled water,	40-55	½	½	¾	1	1	1
Refrigerant, or brine	below 40	1	1	1½	1½	1½	1½

For SI: 1 inch = 25.4 mm, ?F = 1.8?C + 32, 1 ft = 304.8 mm.
1. For piping exposed to outdoor air, increase insulation thickness by ½ inch.
2. Runouts not exceeding 12 feet in length to individual terminal units.

J4.4.9.1 Other insulation thicknesses: Insulation thicknesses in Table J4.4.9 are based on insulation having thermal resistivity in the range of 4.0 to 4.6 $h \cdot ft^{2} \cdot ?F/Btu$ per inch (0.704 to 0.810 $m^{2} \cdot k/W$ per 25 mm) of thickness on a flat surface at a mean temperature of 75?F (24?C).

Minimum insulation thickness shall be increased for materials having values less than 4.0, or may be reduced for materials having values greater than 4.6 as follows.

For materials with thermal resistively greater than 4.6, the minimum insulation thickness may be reduced as follows:

$$\frac{4.6 \times \text{Table 503.9 Thickness}}{\text{Actual Resistivity}} = \text{New Minimum Thickness}$$

For materials with thermal resistively less than 4.0, the minimum insulation thickness shall be increased as follows:

$$\frac{4.0 \times \text{Table 503.9 Thickness}}{\text{Actual Resistivity}} = \text{New Minimum Thickness}$$

J4.5 Service Water Heating

J4.5.1 Scope: The purpose of 780 CMR J4.5 is to provide criteria for design and equipment selection that will produce energy savings when applied to service water heating. Water supplies to ice making machines, refrigerators, and toilets shall be taken from a cold-water line of the water distribution system.

J4.5.2 Water heaters, storage tanks and boilers.

J4.5.2.1 Performance efficiency: Water heaters and hot water storage tanks shall meet the minimum performance of water heating equipment specified in Table J4.5.2. Where multiple criteria are listed, all criteria shall be met.

Excption: Storage water heaters. Storage water heaters and hot water storage tanks having more than 140 gallons (530L) of storage capacity need not meet the standby loss (*SL*) or heat loss (*HL*) requirements of table J4.5.2 if the tank surface area is thermally insulated to *R*-12.5 and if a standing pilot light is not used.

J4.5.2.2 Insulation: Heat loss from unfired hot-water storage tanks shall be limited to a maximum of 6.5 $Btu/h/ft.^{2}$ (20.5 W/m^{2}) of external tank surface area, based on 80?F (176?C) water-air temperature difference.

Exception: Unfired hot water storage tanks having more than 500 gallons (1893 L) of storage capacity thermally insulated to *R*-12.5.

J4.5.2.3 Combination service water heating/ space heating boilers: Service water-heating equipment shall not be dependent on year-round operation of space heating boilers; that is, boilers that have as another function winter space heating.

Exceptions:
1. Systems for which the input rating of the combined system is less than 150,000 Btu.
2. Systems for which the combined system capacity (input rating or storage volume) is less than twice that of the smaller of the separate

heaters required in a system with separate space and water heating.

3. Systems with service/space heating boilers having a standby loss (Btu/h) (W) less than:

$$\frac{13.3\ pmd\ 400}{n}$$

determined by the fixture count method where:
pmd =probable maximum demand in gallons/hour as determined in accordance with Chapter 37 of the ASHRAE HVAC Systems and Applications Handbook, as listed in Appendix A.

n =fraction of year when outdoor daily mean temperature exceeds 64.9?F (18.3?C)

The standby loss is to be determined for a test period of 24 hour duration while maintaining a boiler water temperature of 90?F (32.2?C) above an ambient of 60 to 90?F (15.6 to 32.2?C) and a five-foot (1524 mm) stack on appliance.

TABLE J4.5.2
MINIMUM PERFORMANCE OF WATER HEATING EQUIPMENT

CATEGORY	TYPE	FUEL	INPUT RATING	V_T[1]	INPUT TO V_r RATIO (Btu/h/gal)	TEST METHOD	ENERGY FACTOR[3]	THERMAL EFFICIENCY E_T%	STANDBY LOSS %/hr[7]
NAECA Covered Water Heating Equipment[4]	all	electric	≤12 kW	all[6]		Code of Federal Regulations, 10 CFR Part 430 Subpart B, Appendix E	≥0.93-0.00132V		
	storage	gas	≤75,000 Btuh	all[6]			≥0.62-0.0019V		
	instantaneous	gas	≤200,000 Btuh[6]	all			≥0.62-0.0019V		
	storage	oil	≤105,000 Btuh	all			≥0.59-0.0019V		
	instantaneous	oil	≤210,000 Btuh	all			≥0.59-0.0019V		
pool heater		gal/oil	all	all		ANSI Z21.56, as listed in Appendix A		≥78%	
Other Water Heating Equipment[5]	storage	electric	all	all		ANSI Z21.10.3, as listed in Appendix A			≤0.30+27/V_r
			≥155,000 Btuh	all					
	storage/ instantaneous	gas/oil	>155,000 Btuh	all	<4,000			≥78%	≤1.3+114/V_r
				<10	<4,000			≥78%	≤1.3+95/V_r
				≥10	≥4,000			≥80%	—
					≥4,000			≥77%	≤2.3+67/V_r
Unfired Storage Tanks				all					≤6.5 Btuh/ square foot[8]

For SI: 1 Btuh/ft.^{2} = 3.155 W/m^2, 1 Btuh = 0.2931 W, 1 gallon = 3.785 L, ?F. = 1.8?C + 32.

1. V_T is the storage volume in gallons as measured during the standby loss test. For the purpose of estimating the standby loss requirement using the rated volume shown on the rating plate, V_T should be no less than 0.95V for gas and oil water heaters and no less than 0.90V for electric water heaters.

3. V is rated storage volume in gallons as specified by the manufacturer.

4. Consistent with National Appliance Energy Conservation Act (NAECA) of 1987.

5. All except those water heaters covered by NAECA.

6. Code of Federal Regulations, 10 CFR Part 430 Subpart B, Appendix E, as listed in Appendix A, applies to electric and gas storage water heaters with rated volumes 20 gallons and gas instantaneous water heaters with input ratings of 50,000 to 200,000 Btuh.

7. When testing an electric storage water heater for standby loss using the test procedure of Section 2.9 of ANSI Z21.10.3-1990 Gas Water Heaters, Volume III, Circulating Tank, Instantaneous and Large Automatic Storage-Type Water Heaters, the electrical supply voltage shall be maintained within ±1% of the center of the voltage range specified on the voltage range specified on the water heater nameplate. Also, when needed for calculations, the thermal efficiency (Et) shall be 98%.

When testing an oil water heater using the test procedures of Section 2.8 and 2.9 of ANSI Z21.10.3, as listed in Appendix A, the following modifications will be made:

A vertical length of flue pipe shall be connected to the flue gas outlet of sufficient height to establish the minimum draft specified in the manufacturer's installation instructions. All measurements of oil consumption will be taken by instruments with an accuracy of ±1% or better.

The burner rate shall be adjusted to achieve an hourly Btu input rate within ±2% of the manufacturer's specified input rate with the CO_2 reading as specified by the manufacturer with smoke no greater than 1 and the fuel pump pressure within ±1% of the manufacturer's specification.

8. Heat loss of tank surface area (Btuh/ft.^{2}) based on 80?F. water-air temperature difference.

J4.5.3 Automatic controls: Service water-heating systems shall be equipped with automatic temperature controls capable of adjustment from the lowest to the highest acceptable temperature settings for the intended use. Temperature setting range shall be in accordance with Table 2 in Chapter 37 of ASHRAE HVAC Systems and Applications Handbook, as listed in Appendix A.

J4.5.4 Shutdown: A separate switch shall be provided to permit turning off the energy supplied to electric service water-heating systems. A separate valve shall be provided to permit turning off the energy supplied to the main burner(s) of all other types of service water-heating systems.

J4.5.5 Pump operation: Circulating hot-water systems shall be arranged so that the circulation pump(s) can be conveniently turned off, automatically or manually, when the hot-water system is not in operation.

J4.5.6 Pipe insulation: For re-circulating systems, piping heat loss shall be limited to a maximum of 17.5 Btu/h per linear foot (5.13 W per m^2) of pipe in accordance with Table J4.5.6, which is based on design external temperature no lower than 65?F (18.3?C). Other design temperatures must be calculated.

Exception: Piping insulation is not required when the heat loss of the piping, without insulation, does not increase the annual energy requirements of the building.

TABLE J4.5.6
MINIMUM PIPE INSULATION
(Thickness in Inches)

SERVICE WATER HEATING TEMPERATURES ?F	PIPE SIZES[1]			
	Noncirculating Runouts	Circulating Mains and Runouts		
	Up to 1"	Up to 1¼"	1½" to 2"	Over 2"
170-180	0.5	1.0	1.5	2.0
140-160	0.5	0.5	1.0	1.5
100-130	0.5	0.5	0.5	1.0

For SI: 1 inch = 25.4 mm, ?F = 1.8?C + 32.

1. Nominal iron pipe size and insulation thickness. Conductivity K ? 0.27

J4.5.7 Swimming pools.

J4.5.7.1 All pool heaters shall be equipped with an ON-OFF switch mounted for easy access to allow shutting off the operation of the heater without adjusting the thermostat setting and to allow restarting without re-lighting the pilot light.

J4.5.7.2 Pool covers: Heated swimming pools shall be equipped with a pool cover.

Exception: Outdoor pools deriving over 20% of the energy for heating from renewable sources (computed over an operating season) are exempt from this requirement.

J4.5.7.3 Time clocks: Time clocks shall be installed so that the pump can be set to run in the off-peak electric demand period and can be set for the minimum time necessary to maintain the water in a clear and sanitary condition in keeping with applicable health standard.

J4.5.8 Conservation of hot water.

J4.5.8.1 Showers: Shower heads shall have a maximum flow rate of 2.5 gallons per minute (gpm) (0.158 L/s) at a pressure of 80 pounds per square inch (psi) (551 kPa) when tested in accordance with ASME A112.18.1, as listed in Appendix A.

J4.6 Electrical Power and Lighting.

J4.6.1 Electrical energy consumption: In multifamily dwellings, provisions shall be made to determine the electrical energy consumed by each tenant by separately metering individual dwelling units.

Exception: Motels, hotels, college dormitories and other transient facilities.

J4.6.2 Lighting power budget: The lighting system shall meet the applicable provisions of 780 CMR 1308.

Exception: One-and Two-Family dwellings and the dwelling portion of multifamily residential buildings.

780 CMR J5.0 RESIDENTIAL BUILDING DESIGN BY PRESCRIPTIVE PACKAGE

(Also see 780 CMR J1.1.3)
Compliance Approach #1

Notes:

1. The Prescriptive Package Approach is expectedly the most conservative for building envelope compliance. It does not require calculation of a building's thermal performance, but allows the user to simply select a set of components from a pre-determined group after establishing the weather site and glazing area of the building.
2. There is no interpolation or extrapolation allowed between packages in Table J5.2.1b.
3. The Prescriptive Package Approach (780 CMR J5.0) is intended for one and two-family detached buildings heated with fossil fuels and having glazing representing no more than 18% of the gross wall area. Also, such buildings must be either wood frame or mass wall construction (concrete, masonry, log): metal frame buildings are excluded.
4. For one and two-family buildings that do not meet the requirements in Note 3, and for all multi-family buildings, refer to 780 CMR J1.1.3. compliance alternatives 2. through 5.
5. Table J5.2.1b is based on a number of assumptions about the buildings it covers. These assumptions are stated fully in the Footnotes to that table, and should be reviewed to assure that the Table is suitable for use with any given proposed building.

J5.1 Scope.

J5.1.1 General: Buildings constructed to 780 CMR J5.0 that are heated and/or mechanically cooled shall meet the applicable requirements of 780 CMR J5.0 and 780 CMR J4.0.

J5.2 Exterior Envelope Requirements

J5.2.1 General: The various building assemblies (window, wall, ceiling, floor, etc.) shall conform to the thermal transmittance and resistance values in Table J5.2.1b.

TABLE J5.2.1a
HEATING DEGREE DAYS BASE 65 (HDD_{65})

City	HDD_{65}		City	HDD_{65}
Amherst	6404		Hyannis	6137
Barre Falls Dam	7699		Knightville Dam	7439
Bedford	6521		Lawrence	6322
Birch Hill Dam	7739		Lowell	6339
Blue Hill	6398		Middleton	6268
Boston	5641		Nantucket	5848
Brockton	6225		New Bedford	5426
Chatham	6058		Plymouth	6333
Chester	7279		Provincetown	6044
Clinton	6698		Reading	6573
Cummington Hill	7658		Rochester	6267
East Brimfield Lake	7027		South Weymouth	5936
East Wareham	6297		Springfield[1]	5754
Edgartown	5916		Stockbridge	7060
Falmouth	5713		Taunton	6346
Framingham	6262		Tully Lake	7552
Great Barrington	7445		West Medway	6650
Haverhill	6413		Worcester	6979
Hingham	6072			

Note 1: Table J5.2.1a is only utilized to support Table J5.2.1b.
Note 2: The heating degree day value for Springfield is only to be used for the cities and towns of Chicopee, Holyoke, West Springfield, Springfield, Agawam and Longmeadow. For all other surrounding towns of Springfield, design to the HDD value of Amherst.

Table J5.2.1b
Prescriptive Packages for One- and Two-Family Residential Buildings Heated with Fossil Fuels

	MAXIMUM				MINIMUM			
Package	Glazing Area[1] (%)	Glazing U-value[2]	Ceiling R-value[3]	Wall R-value[4]	Floor R-value[5]	Basement Wall R-value[6]	Slab Perimeter R-value[7]	Heating/Cooling Equipment Efficiency[8]
				Less than 5501 Heating Degree Days[9]				
A	up to 12%	0.50	38	13	19	10	6	minimum from J4 Tables

	MAXIMUM			MINIMUM				
Package	Glazing Area[1] (%)	Glazing U-value[2]	Ceiling R-value[3]	Wall R-value[4]	Floor R-value[5]	Basement Wall R-value[6]	Slab Perimeter R-value[7]	Heating/Cooling Equipment Efficiency[8]
B	up to 12%	0.52	30	13	19	10	6	82 AFUE
C	12.1 to 15%	0.42	38	13	19	10	6	minimum from J4 Tables
D	12.1 to 15%	0.50	38	13	19	10	6	85 AFUE
E	15.1 to 18%	0.39	38	13	25	N/A	N/A	minimum from J4 Tables
F	15.1 to 18%	0.42	38	13	19	10	6	85 AFUE
				5501 to 5700 Heating Degree Days[9]				
G	up to 12%	0.46	38	13	19	10	6	minimum from J4 Tables
H	up to 12%	0.52	30	13	19	10	6	85 AFUE
I	12.1 to 15%	0.41	38	13	25	N/A	N/A	minimum from J4 Tables
J	12.1 to 15%	0.50	38	19	19	10	6	minimum from J4 Tables
K	12.1 to 15%	0.46	38	13	19	10	6	85 AFUE
L	15.1 to 18%	0.36	38	13	25	N/A	N/A	minimum from J4 Tables
M	15.1 to 18%	0.43	38	19	19	10	6	minimum from J4 Tables
N	15.1 to 18%	0.42	38	13	25	N/A	N/A	85 AFUE
O	15.1 to 18%	0.46	38	13	19	10	6	90 AFUE
P	15.1 to 18%	0.50	30	19	19	10	6	87 AFUE
				5701 to 6500 Heating Degree Days[9]				
Q	up to 12%	0.40	38	13	19	10	6	minimum from J4 Tables
R	up to 12%	0.52	30	19	19	10	6	minimum from J4 Tables
S	up to 12%	0.50	38	13	19	10	6	85 AFUE
T	12.1 to 15%	0.36	38	13	25	N/A	N/A	minimum from J4 Tables
U	12.1 to 15%	0.46	38	19	19	10	6	minimum from J4 Tables
V	12.1 to 15%	0.44	38	13	25	N/A	N/A	85 AFUE
W	12.1 to 15%	0.52	30	19	19	10	6	85 AFUE
X	15.1 to 18%	0.32	38	13	25	N/A	N/A	minimum from J4 Tables
Y	15.1 to 18%	0.42	38	19	25	N/A	N/A	minimum from J4 Tables
Z	15.1 to 18%	0.42	38	13	19	10	6	90 AFUE
AA	15.1 to 18%	0.50	30	19	19	10	6	90 AFUE
				Greater Than 6500 Heating Degree Days[9]				
BB	up to 12%	0.31	38	13	25	N/A	N/A	minimum from J4 Tables
CC	up to 12%	0.43	38	19	19	10	6	minimum from J4 Tables
DD	up to 12%	0.45	38	13	19	10	6	90 AFUE
EE	up to 12%	0.50	30	19	19	10	6	85 AFUE
FF	12.1 to 15%	0.40	38	13	25	N/A	N/A	90 AFUE
GG	12.1 to 15%	0.50	38	19	19	10	6	90 AFUE
HH	12.1 to 15%	0.43	38	19	19	10	6	85 AFUE

	MAXIMUM				MINIMUM			
Package	Glazing Area[1] (%)	Glazing U-value[2]	Ceiling R-value[3]	Wall R-value[4]	Floor R-value[5]	Basement Wall R-value[6]	Slab Perimeter R-value[7]	Heating/Cooling Equipment Efficiency[8]
II	15.1 to 18%	0.35	38	13	25	N/A	N/A	90 AFUE
JJ	15.1 to 18%	0.35	30	19	19	10	6	90 AFUE
KK	15.1 to 18%	0.42	38	19	19	10	6	90 AFUE

N/A - This package may not be used for buildings with insulated Basement Walls or Slabs.

Footnotes to Table J5.2.1b:

1. Glazing area is the ratio of the rough opening area of the glazing assemblies (including sliding-glass doors, skylights, and basement windows if located in walls that enclose conditioned space, but excluding opaque doors) to the exterior wall gross area, expressed as a percentage. Up to 1% of the total glazing area may be excluded from the U-value requirement. For example, 3 ft^2 of decorative glass may be excluded from the U-value requirement of a building design with 300 ft^2 of glazing area.
2. After January 1, 1999, glazing U-values must be tested and documented by the manufacturer in accordance with the National Fenestration Rating Council (NFRC) test procedure, or taken from Table J1.5.3a. U-values are for whole units: center-of-glass U-values cannot be used.
3. The ceiling R-values do not assume raised or oversized framing construction. If the insulation achieves the full insulation thickness over the exterior walls without compression, or if non-compressible insulation is used to achieve full R-value, R-30 insulation may be substituted for R-38 insulation. Ceiling R-values represent the sum of cavity insulation plus insulating sheathing (if used). For ventilated ceilings, insulating sheathing must be placed between the conditioned space and the ventilated portion of the roof.
4. Wall R-values represent the sum of the wall cavity insulation plus insulating sheathing (if used). Do not include exterior siding, structural sheathing, and interior drywall. For example, an R-19 requirement could be met EITHER by R-19 cavity insulation OR R-13 cavity insulation plus R-6 insulating sheathing. Wall requirements apply to wood-frame or mass (concrete, masonry, log) wall constructions, but do not apply to metal-frame construction.
5. The floor requirements apply to floors over unconditioned spaces (such as unconditioned crawlspaces, basements, or garages). Floors over outside air must meet the ceiling requirements.
6. The entire opaque portion of any individual basement wall with an average depth less than 50% below grade must meet the same R-value requirement as above-grade walls. Windows and sliding glass doors of conditioned basements must be included with the other glazing. Basement doors must meet the door U-value requirement described in Note b.
7. The R-value requirements are for unheated slabs. Add an additional R-2 for heated slabs.
8. If the building utilizes electric resistance heating use the compliance approaches found in 780 CMR J6, 7, 8, or 9. If you plan to install more than one piece of heating equipment or more than one piece of cooling equipment, the equipment with the lowest efficiency must meet or exceed the efficiency required by the selected package.
9. For Heating Degree Day requirements of the closest city or town see Table J5.2.1a

NOTES:

a) Glazing areas and U-values are maximum acceptable levels. Insulation R-values are minimum acceptable levels. R-value requirements are for insulation only and do not include structural components.

b) Opaque doors in the building envelope must have a U-value no greater than 0.35. Door U-values must be tested and documented by the manufacturer in accordance with the NFRC test procedure or taken from the door U-value in Table J1.5.3b. If a door contains glass and an aggregate U-value rating for that door is not available, include the glass area of the door with your windows and use the opaque door U-value to determine

compliance of the door. One door may be excluded from this requirement (i.e., may have a U-value greater than 0.35).
c) If a ceiling, wall, floor, basement wall, slab-edge, or crawl space wall component includes two or more areas with different insulation levels, the component complies if the average R-value is greater than or equal to the R-value requirement for that component. Average R-value must be calculated by applying area-weighted U-values to the components, and determining the reciprocals. Glazing or door components comply if the area-weighted average U-value of all windows or doors is less than or equal to the U-value requirement (0.35 for doors).

780 CMR J6.0 RESIDENTIAL BUILDING DESIGN BY COMPONENT PERFORMANCE

(Manual Trade-off or
"Paper and Pencil" Approach)
(Also see 780 CMR J1.1.3)
Compliance Approach #2

Notes:

1. The Component Performance Approach shown in 780 CMR J6.0 is a design-specific alternative to the Prescriptive Package Approach of 780 CMR J5.0.
2. The Component Performance Approach allows for trade-offs between all building envelope components, and heating and cooling equipment efficiencies. This approach allows greater flexibility than that allowed in the Prescriptive Packages listed in Table J5.2.1b.
3. The Component Performance Approach may be used only for wood or metal framed buildings, 16" or 24" on center. For other framing materials or configurations, use 780 CMR J7.0, J8.0, or J9.0.

J6.1 Scope

J6.1.1 General: Buildings constructed to 780 CMR J6.0 that are heated and/or mechanically cooled shall meet all applicable requirements of 780 CMR J6.0 and 780 CMR J4.0.

J6.2 Exterior Envelope Requirements

J6.2.1 General: To determine thermal transmittance compliance with the various wall, roof and floor assemblies, the Trade-Off Worksheet must be completed using the figures and tables provided.

J6.2.2 Instructions for Using the Trade-off Approach:

STEP 1: Find your climate zone based on the county in which your building is to be located shown in Figure J6.2.2.

STEP 2: Complete the general information at the top of the Trade-off Worksheet.

STEP 3: Complete the PROPOSED section of the Trade-off Worksheet. Provide the area, R-value and U-value of each component. Use net areas for walls and roof assemblies that contain windows, doors, or skylights. U-values can be found in Tables J6.2.2a through J6.2.2g. R-values in tables are based on cavity insulation plus insulating sheathing (if used).

If more than one type of insulation or glass is used for a building component (i.e. two different R-values in the ceiling) use the additional blank lines for each R or U value provided in each block of the proposed section.

(**Note**: Remember that, for heated basements, foundation walls that are 50% and greater above grade are considered "Walls" while foundation walls less that 50% above grade are considered "Basement Walls."

STEP 4: Compute the total Proposed UA. Multiply all proposed U-values by their

corresponding area. Enter the results in the UA column. Sum the proposed UAs for all components and enter this sum in the *Total Proposed UA* box. Also sum the areas for Ceilings and Walls, and enter in the "Total Area" boxes. Transfer these "Total Areas" to the respective Required "Area" boxes.

STEP 5: Complete the REQUIRED section of the Trade-Off Worksheet. Table J6.2.2h lists building component U-value requirements for each climate zone in Massachusetts. Enter the required U-values in the appropriate *Required U-value* column. Copy the total areas to the *Area* column of the *Required* side.

STEP 6: Multiply U-values in the Required column by their corresponding area; enter results in the UA column. Sum the UAs on the right side of the worksheet.

STEP 7: If high efficient HVAC is to be taken into account, complete the HVAC Trade-off Worksheet. Replace *Total Required UA* with HVAC adjusted UA (the new required UA will increase) from HVAC Trade-off worksheet.

STEP 8: Check for compliance. If the *Total Proposed UA* is less than or equal to the *Total Required UA* then your building complies with the thermal envelope requirements of Appendix J. If not, you must adjust insulation R-values, areas, and/or HVAC system efficiency in your proposed building.

FIGURE J6.2.2
State Map with Climate Zones

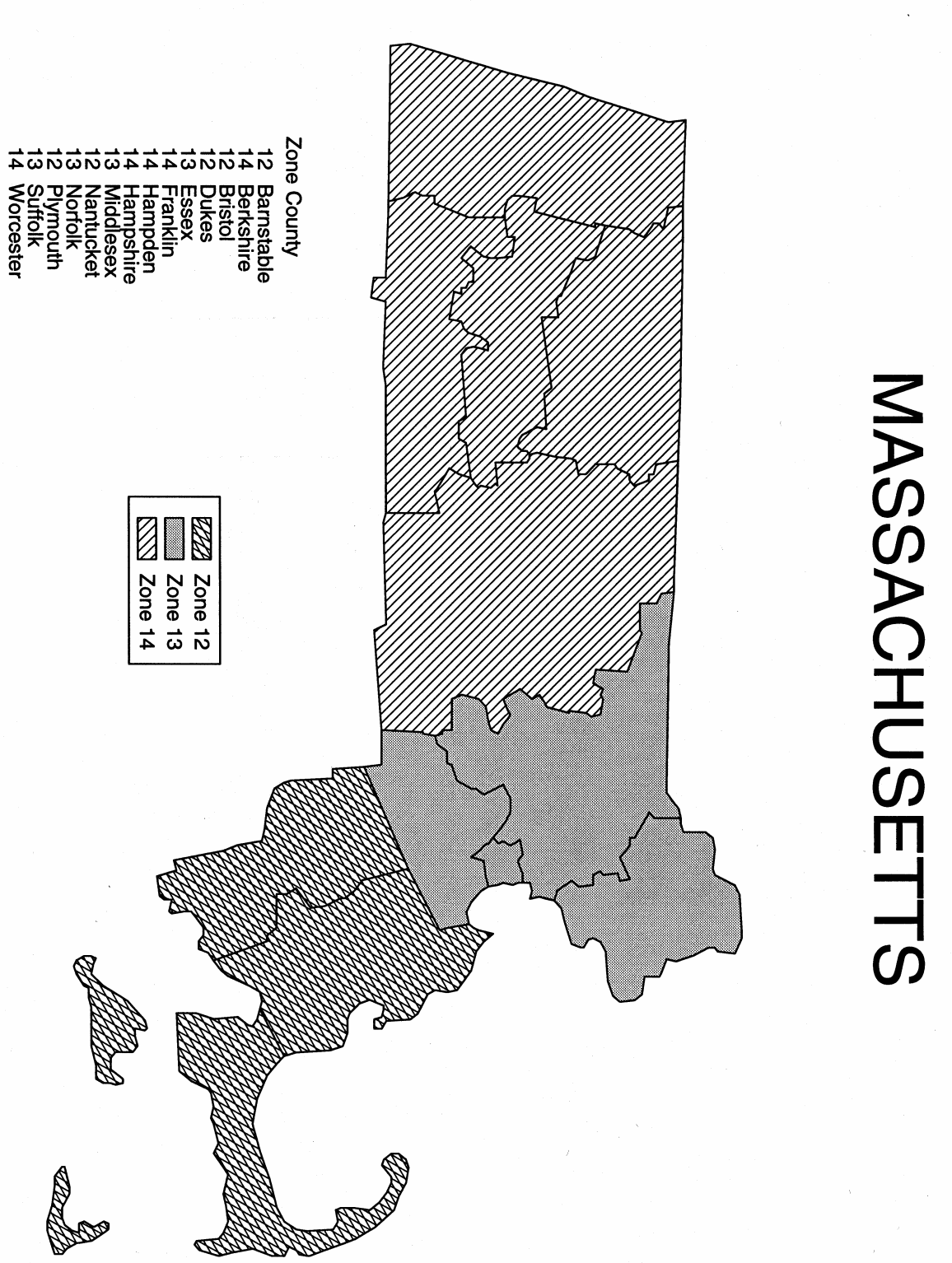


TABLE J6.2.2a
Ceiling U-values

Insulation R-Value[a]	Standard Framing *U-Value*	*Raised Framing* U-Value[b]	Insulation *R-Value*[a]	Standard Framing *U-Value*	*Raised Framing* U-Value[b]
R-0	0.568	0.568	R-33	0.033	0.029
R-7	0.119	0.119	R-34	0.032	0.028
R-8	0.108	0.108	R-35	0.032	0.028
R-9	0.098	0.098	R-36	0.031	0.027
R-10	0.089	0.089	R-37	0.031	0.026
R-11	0.082	0.082	R-38	0.030	0.025
R-12	0.076	0.076	R-39	0.030	0.025
R-13	0.070	0.070	R-40	0.029	0.024
R-14	0.066	0.066	R-41	0.029	0.024
R-15	0.062	0.061	R-42	0.028	0.023
R-16	0.059	0.058	R-43	0.028	0.023
R-17	0.056	0.055	R-44	0.027	0.022
R-18	0.053	0.052	R-45	0.027	0.022
R-19	0.051	0.049	R-46	0.027	0.021
R-20	0.048	0.047	R-47	0.026	0.021
R-21	0.047	0.045	R-48	0.026	0.020
R-22	0.045	0.043	R-49	0.026	0.020
R-23	0.043	0.041	R-50	0.026	0.020
R-24	0.042	0.040	R-51	0.025	0.019
R-25	0.040	0.038	R-52	0.025	0.019
R-26	0.039	0.037	R-53	0.025	0.019
R-27	0.038	0.035	R-54	0.025	0.018
R-28	0.037	0.034	R-55	0.024	0.018
R-29	0.036	0.033	R-56	0.024	0.018
R-30	0.035	0.032	R-57	0.024	0.018
R-31	0.034	0.031	R-58	0.024	0.017
R-32	0.034	0.030	R-59	0.024	0.017

(a) R-values represent the sum of the ceiling cavity insulation plus the R-value of insulating sheathing (if used.) For example, R-19 cavity insulation plus R-5 sheathing is reported as R-24 ceiling insulation. For ventilated ceilings, insulating sheathing must be placed between the conditioned space and the ventilated portion of the roof (typically applied to the trusses or rafters immediately behind the drywall or other ceiling finish material.)
(b) To receive credit for raised framing, the insulation must achieve its full thickness over the exterior walls, or non-compressible insulation must be used to achieve full R-value.

TABLE J6.2.2b
Wood Frame Wall U-values

Insulation R-Value©	16-in. O.C. *Wall U-Value*	*24-in. O.C.* Wall U-Value
R-0	0.238	0.241
R-7	0.105	0.104
R-8	0.099	0.097
R-9	0.094	0.092
R-10	0.090	0.088
R-11	0.089	0.087
R-12	0.085	0.083
R-13	0.082	0.080
R-14	0.079	0.077
R-15	0.077	0.074
R-16	0.066	0.064
R-17	0.064	0.062
R-18	0.062	0.060
R-19	0.060	0.059
R-20	0.059	0.057
R-21	0.057	0.056
R-22	0.056	0.054
R-23	0.055	0.053
R-24	0.054	0.052
R-25	0.053	0.051
R-26	0.052	0.050
R-27	0.051	0.049
R-28	0.050	0.048

(a) U-values are for **uncompressed** insulation.
(b) Wall R-values are the sum of the cavity insulation plus insulating sheathing (if used.)

TABLE J6.2.2c
16 inches O.C. Metal Frame Wall U-values

	Insulating Sheathing R-Value									
Cavity *R-Value*	R-0	*R-2*	R-3	*R-4*	R-5	*R-6*	R-7	*R-8*	R-9	*R-10*
R-0	0.270	0.205	0.170	0.146	0.127	0.113	0.101	0.092	0.084	0.078
R-11	0.120	0.106	0.096	0.087	0.080	0.074	0.069	0.065	0.061	0.057
R-13	0.114	0.100	0.091	0.084	0.077	0.072	0.067	0.063	0.059	0.056
R-15	0.109	0.096	0.088	0.081	0.075	0.070	0.065	0.061	0.058	0.054
R-19	0.101	0.090	0.083	0.077	0.071	0.066	0.062	0.059	0.055	0.052
R-21	0.098	0.088	0.081	0.075	0.070	0.065	0.061	0.058	0.054	0.052
R-25	0.094	0.085	0.078	0.073	0.068	0.063	0.060	0.056	0.053	0.051

TABLE J6.2.2d
24 inches O.C. Metal Frame Wall U-values

	Insulating Sheathing R-Value									
Cavity *R-Value*	R-0	*R-2*	R-3	*R-4*	R-5	*R-6*	R-7	*R-8*	R-9	*R-10*
R-0	0.270	0.205	0.170	0.146	0.127	0.113	0.101	0.092	0.084	0.078
R-11	0.106	0.104	0.086	0.080	0.074	0.069	0.064	0.060	0.057	0.054
R-13	0.100	0.98	0.082	0.076	0.071	0.066	0.062	0.058	0.055	0.052
R-15	0.094	0.093	0.078	0.073	0.068	0.063	0.060	0.056	0.053	0.051
R-19	0.088	0.086	0.074	0.069	0.064	0.060	0.057	0.054	0.051	0.049
R-21	0.085	0.084	0.072	0.067	0.063	0.059	0.056	0.053	0.050	0.048
R-25	0.081	0.080	0.069	0.064	0.060	0.057	0.054	0.051	0.049	0.046

TABLE J6.2.2e
Floor U-values

Insulation R-Value	Floor U-Value
R-0	0.249
R-7	0.096
R-11	0.072
R-13	0.064
R-15	0.057
R-19	0.047
R-21	0.044
R-26	0.037
R-30	0.033

TABLE J6.2.2f
Basement U-values

Insulation R-Value	Basement Wall *U-Value*		*Insulation* R-Value	Basement Wall *U-Value*
R-0	0.360		R-10	0.072
R-1	0.244		R-11	0.067
R-2	0.188		R-12	0.062
R-3	0.155		R-13	0.059
R-4	0.132		R-14	0.055
R-5	0.115		R-15	0.052
R-6	0.102		R-16	0.050
R-7	0.092		R-17	0.047
R-8	0.084		R-18	0.045
R-9	0.077		R-19	0.043
			R-20	0.041

(a) Insulation R-values represent the sum of exterior and/or interior insulation. Basement walls must be insulated from the top of the basement wall to ten ft. below ground level, or to the floor of the basement, whichever is less.

TABLE J6.2.2g
Slab F-values

	Slab U-Value	
Perimeter Insulation *R-Value*	*24-in.* Insulation Depth	48-in. *Insulation Depth*
R-0	1.04	1.04
R-1	0.91	0.89
R-2	0.86	0.83
R-3	0.83	0.79
R-4	0.82	0.76
R-5	0.80	0.74
R-6	0.79	0.73
R-7	0.79	0.71
R-8	0.78	0.70
R-9	0.77	0.69
R-10	0.77	0.68
R-11		0.68
R-12		0.67
R-13		0.66
R-14		0.66
R-15		0.65
R-16		0.65
R-17		0.65

R-18		0.64
R-19		0.64
R-20		0.64

TABLE J6.2.2h
U-value Requirements by Climate Zone

Climate Zone	Ceiling U-value	Single Family Wall *U-value*[1]	Multi-Family Wall *U-value*	*Floor U-value*	Basement Wall *U-value*	Unheated Slab *F-value*	Heated Slab *F-value*
12	0.026	0.13	0.22	0.05	0.079	0.80	0.79
13	0.026	0.12	0.20	0.05	0.078	0.74	0.71
14	0.026	0.11	0.18	0.05	0.077	0.73	0.70

Note 1: Buildings heated by electric resistance require a U=0.105 for a Single Family Wall U-value in all zones.

Manual Trade-Off Worksheet

Permit # _____

Builder Name _____ Date _____

Checked By _____

Builder Address _____

Site Address _____ Zone 12 13 14

Submitted By _____ Phone _____

PROPOSED	REQUIRED

Ceilings, Skylights, and Floors Over Outside Air

Description	Insulation R-Value	U-Value	x Net Area	=	UA	Required U-Value (Table J6.2.2h)	x Area	=	UA
Ceiling (Table J6.2.2a)			ft²						
Floor Over Outside Air (Table J6.2.2a)			ft²						
			ft²						
			ft²						
		Total Area	ft²						

Walls, Windows, and Doors

Description	Insulation R-Value	U-Value	x Net Area	=	UA	Required U-Value	x Area	=	UA
Walls (Table J6.2.2b,c,d)			ft²						
Windows (NFRC or Table J1.5.3a)	-----		ft²						
Doors (NFRC or Table J1.5.3b)	-----		ft²						
Sliding Glass Doors (NFRC or Table J1.5.3a)	-----		ft²						
			ft²						
			ft²						
		Total Area	ft²						

Floors and Foundations

Description	Insulation Depth	Insulation R-Value	U-Value	x Area or Perimeter	= UA	Required U-Value	x Area	= UA
Floor Over Unconditioned Space	(Table J6.2.2e)			ft²				

Basement Wall	(Table J6.2.2f)		ft^2		
Unheated Slab			ft		
(Table J6.2.2g)		in.			
Heated Slab			ft		
(Table J6.2.2g)		in.			
			ft^2		
			ft^2		

Total Proposed UA* must be less than or equal to *Total (or Adjusted) Required UA

Total Proposed UA

✍ OR ✍ ***Total Required UA***

Statement of Compliance: The proposed building design represented in *these documents is consistent with the building plans, specifications,* and other calculations submitted with the permit application.

✍ ***Adjusted Required UA***

_____ _____ _____

Builder/Designer *Company Name* *Date*

HVAC Trade-Off Worksheet

1. Calculate efficiency Increase in percent:

$\frac{EFF_{installed} - EFF_{standard}}{EFF_{standard}}$ = % increase

2. Adjust the % increase according to Trade-off Ratio (Table 1 below):

(% increase X Trade-off Ratio) + 1 = **Adjusted Ratio**

3. Adjust *Total Required UA* (from Manual Trade -Off Worksheet):

Total Required UA X **Adjusted Ratio = Adjusted Required UA**

4. Use Adjusted Required UA as new *Total Required UA*, and check if *Total Proposed UA* is now less than or equal to it.

Total Proposed UA (from Manual Trade-Off Worksheet) [redacted] [redacted] *Total Required UA* [redacted]

Work Space:

Table 1
Trade-off Ratios

City/Town	HDD_{65}	Ratio, ß	City/Town	HDD_{65}	Ratio, ß
Amherst	6404	1.15	Hyannis	6137	1.13
Bedford	6521	1.15	Lawrence	6322	1.14
Blue Hill	6398	1.15	Middleton	6268	1.14
Boston	5641	1.11	Nantucket	5848	1.12
Brocton	6225	1.14	New Bedford	5426	1.10
Chatham	6058	1.13	Plymouth	6333	1.14
Clinton	6698	1.16	Provincetown	6044	1.13
East Wareham	6297	1.14	Rochester	6267	1.14
Edgartown	5916	1.13	Springfield	5754	1.12

Falmouth	5713	1.12	Stockbridge	7060	1.17
Framingham	6262	1.14	Taunton	6346	1.14
Haverhill	6413	1.15	Tully Lake	7552	1.19
			Worcester	6979	1.17

Table 2
NAECA Minimum Equipment Efficiencies[1]

Equipment Type	Minimum	Equipment Type	Minimum
Furnace	78 AFUE	Heat Pump: Heating Mode	6.8 HSPF
Boiler: Except Gas Steam	80 AFUE	Heat Pump: Cooling Mode	10 SEER
Boiler: Gas Steam	75 AFUE	Air Conditioner	10 SEER

1. Note: No Trade-off available for electric Resistance Heating.

780 CMR J7.0 RESIDENTIAL BUILDING DESIGN BY MAScheck SOFTWARE

(Also see 780 CMR J1.1.3)
Compliance Approach #3

Notes:

1. The MAS*check* Software produces similar results to the Component Performance Approach stated in 780 CMR J6.0. However, the software produces results in less time, performs trade-offs quickly, and creates a spread sheet of building components and an inspection report.
2. Installation and operating instructions are contained in the Users Guide, which comes with MAScheck Software.
3. Minimum computer requirements for operating MAScheck Software are:
   (a) a personal computer with the Intel 80386 (386) processor (or higher),
   (b) a 3½" diskette drive,
   (c) 530 kilobytes (KB) of conventional *RAM* memory,
   (d) a hard disk with 1 megabyte (MB) of free disk space,
   (e) *VGA* or Super *VGA* monitor,
   (f) MS-DOS Version 3.1 or later,
   (g) Microsoft-compatible mouse is highly recommended but not required.

J7.1 Scope

J7.1.1 General: Buildings constructed to 780 CMR J7.0 that are heated and/or mechanically cooled shall meet the applicable requirements of 780 CMR J7.0 and 780 CMR J4.0.

J7.2 Exterior Envelope Requirements

J7.2.1 General: To determine thermal transmittance compliance with the various wall, roof and floor assemblies, the MAS*check* Software analysis must be completed, and the "Your Home" UA value must be less than or equal to the "Required" UA value calculated by the software.

780 CMR J8.0 RESIDENTIAL BUILDING DESIGN BY SYSTEMS ANALYSIS

(" Total Energy Analysis")
(Also see 780 CMR J1.1.3)
Compliance Approach #4

Notes:

1. The Systems Design Analysis outlined in 780 CMR J8.0 is the most refined means for Energy Code compliance.
2. If the proposed design takes credit for reduced air changes per hour (below 0.5 ACH), documentation of post-construction testing to verify air change rate shall be provided.
3. Calculation tools shall be approved by the BBRS.

J8.1 Scope

J8.1.1 General: 780 CMR J8 establishes design criteria in terms of total energy use by a residential building, including all of its systems.

J8.2 Systems Analysis

J8.2.1 Energy Analysis: Compliance with 780 CMR J8 will require an analysis of the annual energy usage, hereinafter called an annual energy analysis.

Exception: 780 CMR J4 and J6 establish criteria for different energy-consuming and enclosure elements of the building which, if followed, will eliminate the requirement for an annual energy analysis while meeting the intent of Appendix J.

A building designed in accordance with 780 CMR J8 will be deemed as complying with Appendix J if the calculated annual energy consumption is not greater than a similar building (defined as a "standard design") whose enclosure elements and energy-consuming

systems are designed in accordance with 780 CMR J4 and J6.

For a proposed alternate building design to be considered similar to a "standard design," it shall utilize the same energy source(s) and equipment types for the same functions and have equal floor area and the same ratio of thermal envelope area to floor area, exterior design conditions, occupancy, climate data, and usage operational schedule.

Building designs and energy calculations shall be supported by documentation consistent with Massachusetts registration laws for engin-eers and architects, and otherwise consistent with the requirements of Appendix J.

J8.2.1.1 Input values for Group R buildings: The following input values shall be used in calculating annual energy performance. The requirements of 780 CMR J8 specifically indicate which variables shall remain constant between the standard building and the proposed building calculations. The standard building shall be a base-version of the design that directly complies with the provisions of Appendix J4 and J6. The proposed building may utilize a design that is demonstrated, through calculations satisfactory to the building official, to have equal or lower annual energy use than the standard design.

Glazing Systems

Orientation of the standard design	Equal area on north, south, east and west exposures.
Shading, standard design	Draperies shall be assumed to be closed during periods of mechanical air conditioning operation. Glazing areas in the standard design shall not be provided with extra exterior shading beyond shading that is provided by typical construction practices—such as roof overhangs. Energy performance impacts of added exterior shading for glazing areas may be accounted for in the proposed design for a specific building, provided that the actual installation of such systems is approved by the building official. Results from exterior shading calculations on one proposed building shall not be used for groups of buildings.

Heat Storage (Thermal Mass)

Internal mass	8 pounds per square foot (39 kg/m^2)
Structural mass	3.5 pounds per square foot (17 kg/m^2)

Passive solar building designs shall utilize at least 45 Btu/?F (26 kJ/?C) of additional thermal mass, per square foot (m^2) of added glass area, when added south-facing glass area exceeds 33% of the total glass area in walls.

Building Thermal Envelope—Surface Area and Volume

Floor, walls, ceiling	The standard and proposed designs shall have equal areas.
Foundation and floor type:	The foundation and floor type for both the standard and the proposed design shall be equal.
Glazings, including skylights	The area of glazing in the standard design shall not be greater than the area of glazing in the proposed design. The U_g-value of the standard design shall be selected to permit calculated U_o-wall compliance of the standard design.
Doors of TYPE I structures	The standard design shall have at least 40 square feet (3.7 m^2) of door area.
Building volume	The volumes of both the standard and proposed design shall be equal.

PARAMETER	VALUE
Thermostat (constants)	
Heating set point	68?F. (20?C.)
Cooling set point	78?F. (26?C.)
Night set back	60?F. (16?C.)
Set back duration	7 hours
Number of set-back periods	1(n)[a]
Maximum number of zones	2
Number of thermostats per zone	1
Internal Sensible Heat Gains (constants)	
TYPE I Units	1,500 Btu/hr (440 W)
TYPE II Units	3,000 Btu/hr (879 W)
Domestic Water Heater (calculate, then constants)	
Temperature set point	120?F (49?C)
Daily hot water consumption	Gallons = (30 x n^b - units) + (10 x *n* - bedrooms)

a units = number of living units in proposed design (n).
b bedrooms = number of bedrooms in each living unit.

Site Weather Data (constants)
The typical meteorological year (TMY), or its "Ersatz" equivalent, from the National Oceanic and Atmospheric Administration (NOAA), Table J3.2.1, or an approved equivalent, for the closest available location shall be used.

Distribution System Loss Factors

	Duct Location	
Mode	**Outside**	**Inside**
Cooling	0.80	1.00

Total Adjusted System Efficiency = Equipment Efficiency x Distribution Loss Factor x percent of ducts outside + Equipment Efficiency x Distribution Loss Factor x percent of ducts inside.

Note: Ducts located in a space which contains a positive heat supply shall be considered as in an inside location.

Air Infiltration

Air changes per hour (ACH) for the standard design is 0.50 (for purposes of calculation only).

The Heating and Cooling Systems Efficiency shall be proportionally adjusted for those portions of the ductwork located outside or inside the conditioned space using the values shown above, in the following equation:

If the proposed design takes credit for ACH levels below 0.50, results of a post-construction blower-door test shall be provided to the building official using Standard ASTM E 779, as listed in Appendix A.

J8.2.2 Design: The standard design, conforming to the criteria of Residential Building Design by Component Performance Approach or Residential Building Design by Acceptable Practice and the proposed alternative design shall be designed on a common basis as specified herein:

1. The comparison shall be expressed as Btu input per square foot of gross floor area per year at building site.
2. If the proposed alternative design results in an increase in consumption of one energy source and a decrease in another energy source, even though similar sources are used for similar purposes, the difference in each energy source shall be converted to equivalent energy units for purposes of comparing the total energy used.
3. The different energy sources shall be compared on the basis of energy use at the site where: 1 kWh = 3,413 Btu.

J8.2.3 Analysis Procedure: The analysis of the annual energy usage of the standard and the proposed alternative building and system design shall meet the following criteria:

1. The building heating and cooling load calculation procedures used for annual energy consumption analysis shall be detailed to permit the evaluation of effect of factors specified in 780 CMR J8.2.4.
2. The calculation procedure used to simulate the operation of the building and its service systems through a full-year operating period shall be detailed to permit the evaluation of the effect of system design, climatic factors, operational characteristics, and mechanical equipment on annual energy usage. Manufacturer's data or comparable field test data shall be used when available in the simulation of systems and equipment. The calculation procedure shall be based upon 8,760 hours of operation of the building and its service systems and shall utilize the design methods specified in ASHRAE Handbook of Fundamentals, ASHRAE HVAC Systems and Applications Handbook, ASHRAE, Energy Calculations I, ASHRAE, Energy Calculations II, each as listed in Appendix A.

J8.2.4 Calculation Procedure: The calculation procedure shall cover the following items:

1. Design requirements -- Environmental requirements as required in 780 CMR J3.
2. Climatic data -- Coincident hourly data for temperatures, solar radiation, wind and humidity of typical days in the year representing seasonal variation.
3. Building data -- Orientation, size, shape, mass, air, moisture, and heat transfer characteristics.
4. Operational characteristics -- Temperature, humidity, ventilation, illumination, control mode for occupied and unoccupied hours.
5. Mechanical equipment -- Design capacity, part load profile.
6. Building loads -- Internal heat generation, lighting, equipment, number of people during occupied and unoccupied periods.

J8.2.4.1 Use of Approved Calculation Tool: The same calculation tool shall be used to estimate the annual energy usage for space heating and cooling of the standard design and the proposed design.

J8.2.5 Documentation: Proposed alternative designs, submitted as requests for exception to the standard design criteria, shall be accompanied by an energy analysis comparison report. The report shall provide technical detail on the two building and system designs and on the data used in and resulting from the comparative analysis to verify that both the analysis and the designs meet the criteria of 780 CMR J8 of Appendix J.

Exception: Proposed alternative designs for one and two family dwellings and multifamily buildings having a conditioned floor area of 5,000 square feet (464 m^2) or less are exempted from the full-year analysis described in 780 CMR J8.3 and J8.4. However, comparison of heating, cooling and service water heating equipment energy consumption between the alternative design and the standard design shall be provided.

780 CMR J9.0 RESIDENTIAL BUILDING DESIGN UTILIZING RENEWABLE ENERGY SOURCES

(Also see 780 CMR J1.1.3)
Compliance Approach #5

Notes:
J9.0 Renewable Energy Source Analysis

J9.1 General: A proposed building utilizing solar, geothermal, wind or other renewable energy sources for all or part of its energy source shall meet the requirements of 780 CMR J8.0, except such renewable energy may be excluded from the total annual energy consumption allowed for the building by 780 CMR J8.0.

J9.1.1 To qualify for this exclusion, such renewable energy must be derived from a specific collection, storage, and distribution system. The solar energy passing through windows shall also be considered as qualifying if such windows are provided with:

Operable insulation shutters or other devices which, when drawn or closed, shall cause the window area to reduce maximum outward heat flows to those in accordance with 780 CMR J4.3.2.

J9.1.2 Exclusion shall be granted for solar energy passing through windows provided:

1. The glass is double or triple pane insulating glass with a low emittance coating on one or more air space surfaces of the glass, or insulating glass with a low-emittance plastic film suspended in the air space, and
2. The glass areas are shaded from direct solar radiation during periods when mechanical cooling is requested.

J9.1.3 Other criteria covered in 780 CMR J8.0 shall apply to the proposed alternative designs utilizing renewable energy sources of energy.

1. The Renewable Energy approach outlined in 780 CMR J9.0 allows for portions of a proposed building's energy use to be discounted when performing energy compliance calculations.
2. 780 CMR J9.0 must be used in conjunction with 780 CMR J8.0.

J9.2 Documentation: Proposed alternative designs submitted as requests for exception to the standard design criteria shall be accompanied by an energy analysis, as specified in 780 CMR J8.0. The report shall provide technical detail on the alternative building and systems designs and on the data employed in and resulting from the comparative analysis as to verify that both the analysis and the designs meet criteria of 780 CMR J8.0.

The energy derived from renewable sources and the reduction in conventional energy requirements derived from nocturnal cooling shall be separately identified from the overall building energy use. Supporting documentation on the basis of performance estimates for the aforementioned renewable energy sources or nocturnal cooling means must be submitted.

Exception: Proposed alternative designs for residential buildings of less than 20,000 square feet (1858 m^2) that derive a minimum of 30% of their total annual energy usage from renewable energy sources or from nocturnal cooling shall be exempt from the requirement of a full-year energy system analysis, providing that the annual input of such renewable sources or the extent of such nocturnal cooling can be expected to meet the demands imposed by the proposed alternative design.

780 CMR J10.0 VALIDITY

If a section, subsection, sentence, clause or phrase of Appendix J is, for any reason, held to be unconstitutional, such section shall not affect the validity of the remaining portions of 780 CMR.

J11.0 Home Energy Rating

J11.1 General: A proposed building, for which the builder or the buyer obtains a Home Energy Rating by an accredited Home Energy Rating System (HERS), will be considered to comply with the intent of Appendix J if the rating score on the building is 83.0 or more points.

J11.1.1 Accreditation: Accreditation of the rating organization or agency with the Residential Energy Services Network (RESNET) or the Massachusetts Division of Energy Resources is required for acceptance of the energy rating as a compliance tool for *Appendix J*.

J11.1.2 Rating Score: The minimum compliance score of 83 points will be based on the national HERS Council's guidelines for Home Energy Ratings, and the rating score shall be determined with an acceptable software analysis program as required by RESNET accreditation procedures, on a scale of 0-100 points.

J11.2 Documentation: Compliance report which includes a proposed Energy Rating score of 83.0 or more points, a description of the building's energy features, and a statement that the rating score is "based on plans" will be required for issuance of a building permit. A copy of the final rating certificate indicating the score of 83.0 or more points for the finished building will be submitted to the building official before the Certificate of Occupancy is issued.

APPENDIX J REFERENCED STANDARDS	
Standard Reference Number	**Where Referenced in Appendix J (by Section Number)**
ACCA Manual D	J4.4.8
ANSI/ASME PTC 4.1	Table J4.4.3.2a
ANSI/AHAM RAC-1	Table J4.4.3.4e
ANSI Z21.10.3	J4.5.2
ANSI Z21.47	Table J4.4.2.2c
ANSI Z21.56	J4.5.2
ANZI Z21.13	Tables J4.4.3.2a; J4.4.3.3b
ANZI Z83.8	Table J4.4.3.2b
ANZI Z83.9	Table J4.4.3.2b
ASHRAE HVAC Applications Handbook	J4.4.8
ASHRAE Handbook HVAC Systems and Equipment	J4.4.8
ASHRAE 55	J2.0
ASTM E 779	J8.2.1.1
ARI 210/240	Tables J4.4.3.3a; J4.4.3.4a-d
ARI 320	Tables J4.4.3.3c; J4.4.3.4c
ARI 325	Tables J4.4.3.3d; J4.4.3.4d
ARI 340	Tables J4.4.3.3d; J4.4.3.4f
ARI 360	Table J4.4.3.4f (also see 780 CMR 13, Table 1311.6)
ARI 365	Table J4.4.3.4f
ARI 380	J2.0; Table J4.4.3.3b
ARI 550	Table J4.4.3.4f (also see 780 CMR 13, Table 1311.6)
CTI Standard 201	Tables J4.4.3.4b,c and f (also see 780 CMR 13, Table 1311.6)
Code of Federal Regulations, 10 CFR Part 430, Subpart B, Test Procedures	J2.0; Tables J4.4.3.2a and c; Table J4.5.2
NAIMA Fibrous Glass Duct Construction Standards	J4.4.8
SMACNA Duct Construction Standards, Metal and Flexible	J4.4.8
SMACNA Fibrous Glass Duct Construction Standards	J4.4.8
UL 726	Table J4.4.3.2a
UL 727	Table J4.4.3.2c

UL 731	Tables J4.4.3.2b; J4.4.3.4f
UL 795	Table J4.4.3.2a

ACCA Air Conditioning Contractors of America, Washington, DC
ANSI American National Standards Institute, Inc.., New York, NY
ASHRAE American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., Atlanta, GA
ASTM American Society for Testing and Materials, Philadelphia, PA
ARI Air Conditioning and Refrigeration Institute, Arlington, VA
CTI Cooling Tower Institute, Houston, TX
NAIMA North American Insulation Manufacturers Association, Alexandria, VA
SMACNA Sheet Metal and Air Conditioning Contractors National Association, Inc., Chantilly, VA
UL Underwriters Laboratories, Northbrook, IL